Evaluation of the James River Chlorophyll Assessment Methodology

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James River Chlorophyll RAP Meeting

June 21, 2016

Presentation Outline

- Brief background
- Description of current assessment procedure
- Description of proposed alternative procedure
- Questions/Comments

What is "Assessment Methodology"?

"For each WQS, the state, territory, or authorized tribe should describe how it assesses attainment with the standard. The description may be included in the approved WQS or in other implementing regulations or policies and procedures such as the state, territory, or authorized tribe's continuous planning process or consolidated assessment and listing methodology. This includes defining the water quality indicators it measures and the procedures for analyzing and interpreting data in order to decide whether standards are met or water quality is impaired. This should include collection and analysis of multiple types of data providing information relevant to assessing attainment with approved WQS…."

USEPA—2002 "Consolidated Assessment and Listing Methodology–Toward a Compendium of Best Practices"

http://water.epa.gov/type/watersheds/monitoring/calm.cfm

WATER QUALITY STANDARDS (WQS)

Establishes acceptable pollutant concentrations

ASSESSMENT METHODOLOGY

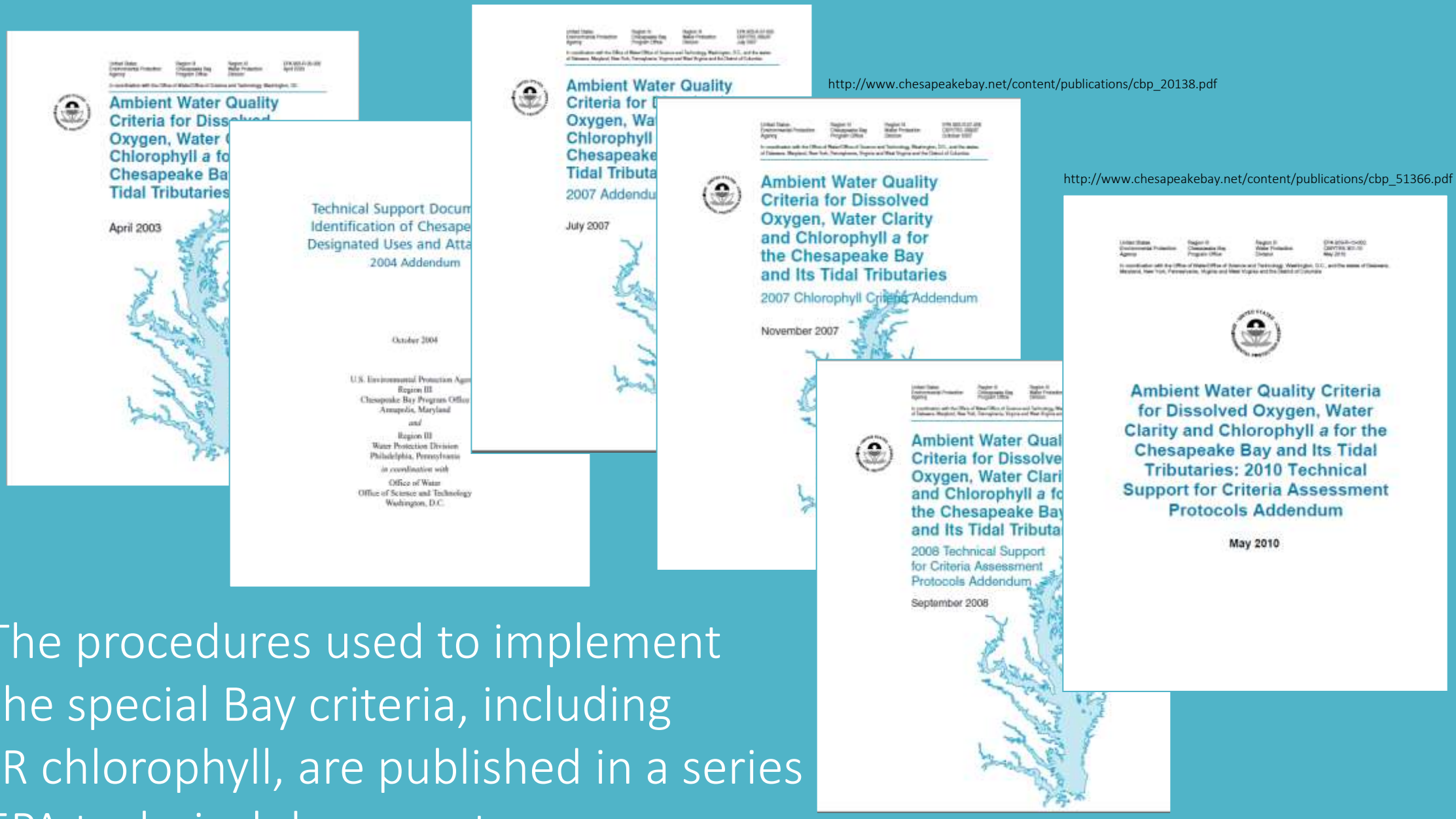
The procedures DEQ uses to implement the WQS

Excerpt from 9 VAC 25-260 Virginia Water Quality Standards

bb. The following site specific numerical chlorophyll a criteria apply March 1 through May 31 and July 1 through September 30 as seasonal means to the tidal James River (excludes tributaries) segments JMSTF2, JMSTF1, JMSOH, JMSMH, JMSPH and are implemented in accordance with subsection D of 9VAC25-260-185.

Designated Use	Chlorophyll a µ/l	Chesapeake Bay Program Segment	Temporal Application
Open Water	10	JMSTF2	March 1 - May 31
	15	JMSTF1	
	15	JMSOH	
	12	JMSMH	
	12	JMSPH	
	15	JMSTF2	July 1 - September 30
	23	JMSTF1	
	22	JMSOH	
	10	JMSMH	
	10	JMSPH	

3. Attainment of these criteria shall be assessed through comparison of the generated cumulative frequency distribution of the monitoring data to the applicable criteria reference curve for each designated use. If the monitoring data cumulative frequency curve is completely contained inside the reference curve, then the segment is in attainment of the designated use. The reference curves and procedures to be followed are published in the USEPA, Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and Its Tidal Tributaries, EPA 903-R-03-002, April 2003 and the 2004 (EPA 903-R-03-002 October 2004) and 2007 (CBP/TRS 285-07, EPA 903-R-07-003), 2007 (CBP/TRS 288/07, EPA 903-R-07-005), 2008 (CBP/TRS 290-08, EPA 903-R-08-001, and 2010 (CBP/TRS 301-10, EPA 903-R-10-002) addenda. An exception to this requirement is in measuring attainment of the SAV and water clarity acres, which are compared directly to the criteria.



http://www.chesapeakebay.net/content/publications/cbp_20138.pdf

http://www.chesapeakebay.net/content/publications/cbp_51366.pdf

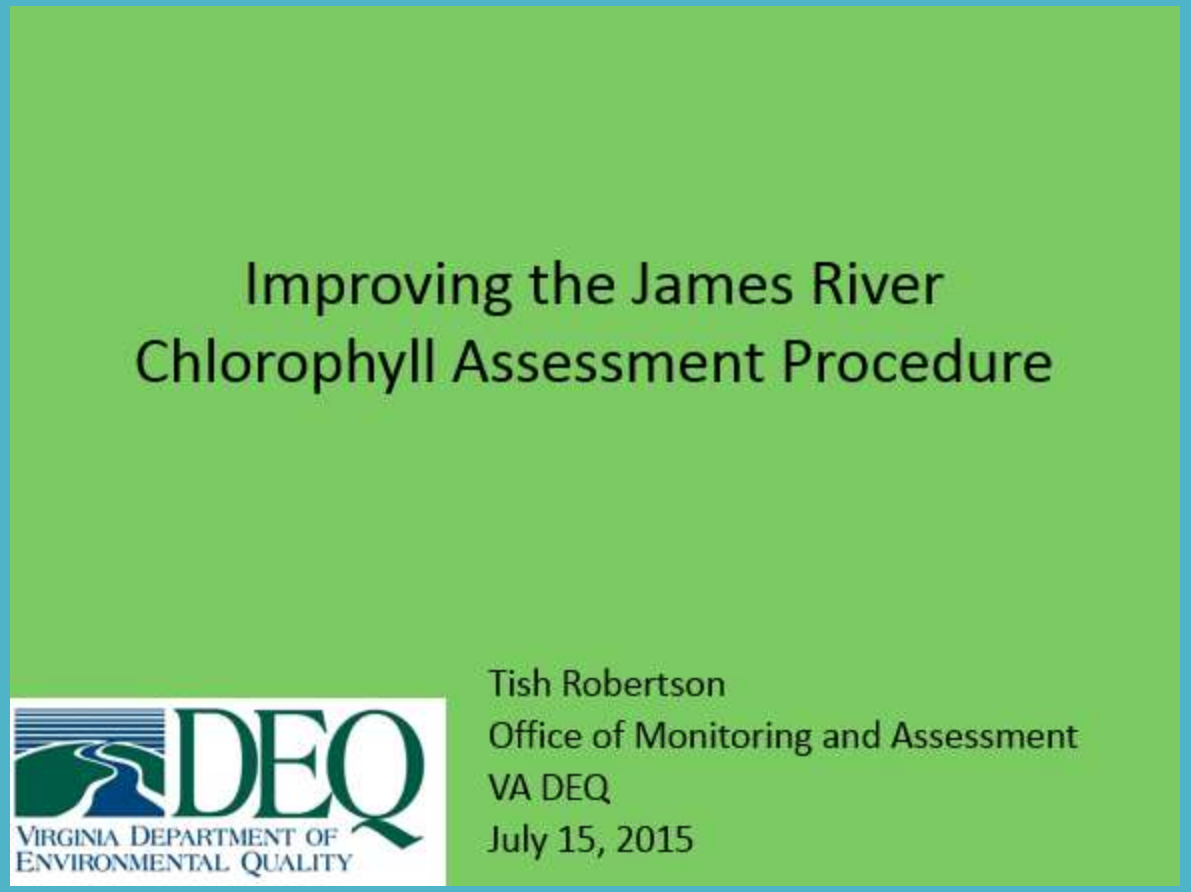
http://www.chesapeakebay.net/channel_files/20963/2008_addendum_ambient_water_quality_criteria.pdf

The procedures used to implement the special Bay criteria, including JR chlorophyll, are published in a series EPA technical documents.

We have been using the current procedure since 2005, when the criteria were first adopted.

Ten years of additional knowledge provide the opportunity to re-evaluate the methodology and revise, if need be.

On July 15, 2015, DEQ hosted a webinar for the SAP to walk everyone through the methodology.



http://www.deq.virginia.gov/Portals/0/DEQ/Water/WaterQualityStandards/JamesRiverChlorophyllStudy/James_R_Chl_Assess_Webinar_15JUL2015.pdf

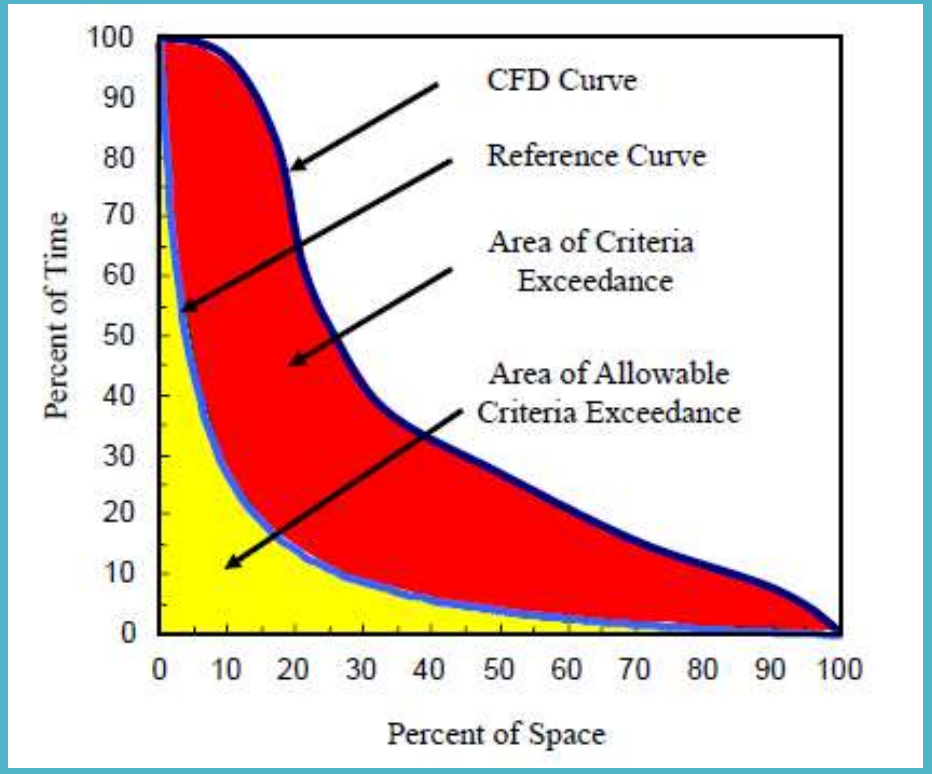
The known methodological weaknesses of the assessment framework were shared with the group, as well as a “straw man” proposal for addressing these weaknesses.

Feedback was solicited and received.

What’s the framework?

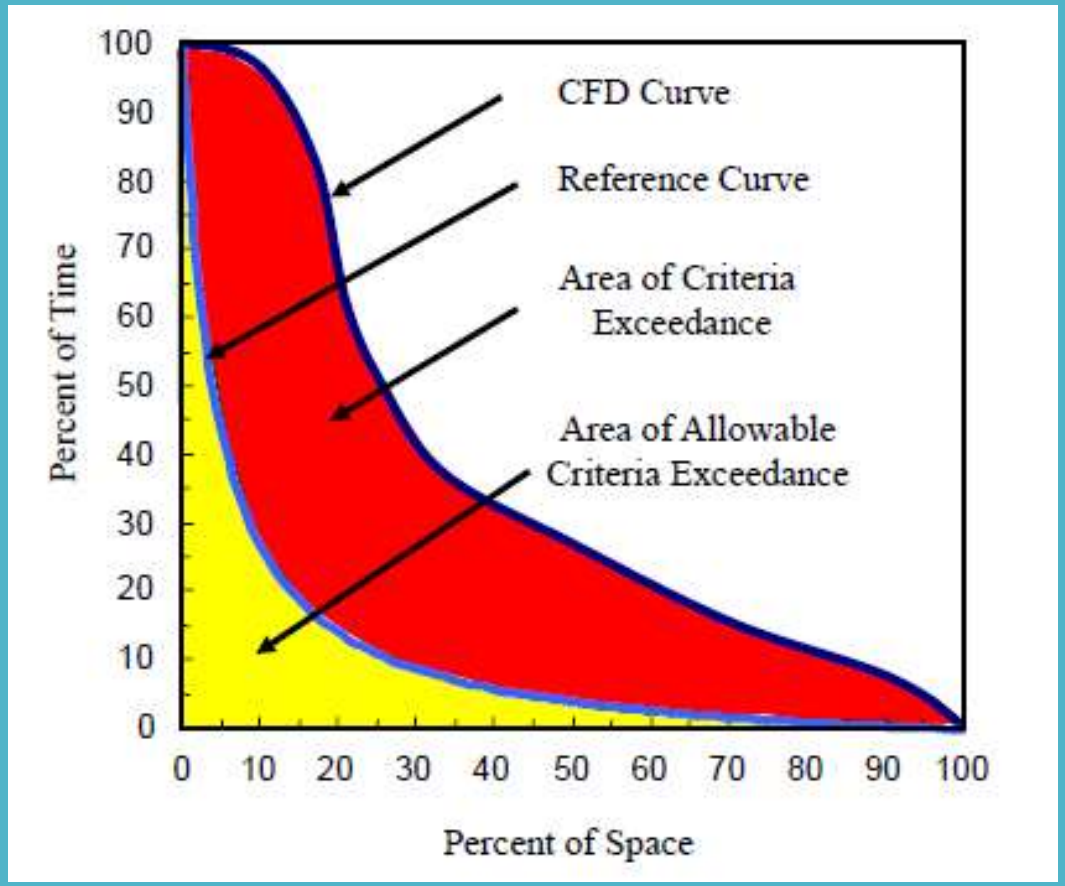
What's the framework?

The Cumulative Frequency Diagram carves out the "allowable" exceedance frequency in space and time.



Tango, Peter J. and Richard A. Batiuk, 2013. Deriving Chesapeake Bay Water Quality Standards. Journal of the American Water Resources Association (JAWRA) 1-18.

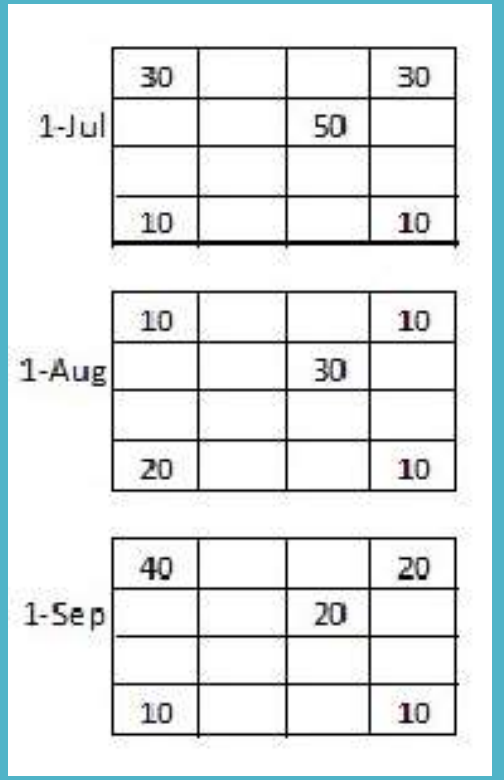
- The CFD was developed by the Bay Program for the purpose of dissolved oxygen assessments.
- DEQ adopted the CFD for JR chlorophyll.
- The CFD is as experimental as it is innovative.



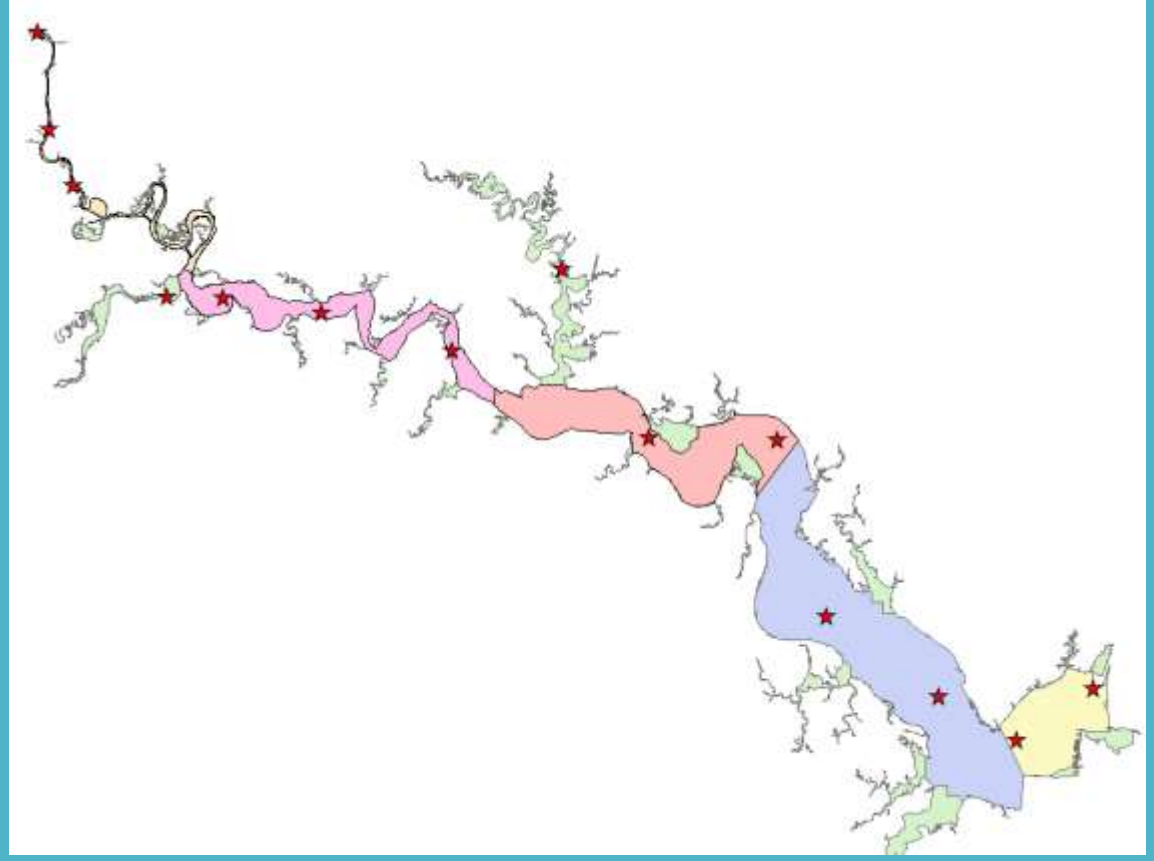
How does it work?

Steps:

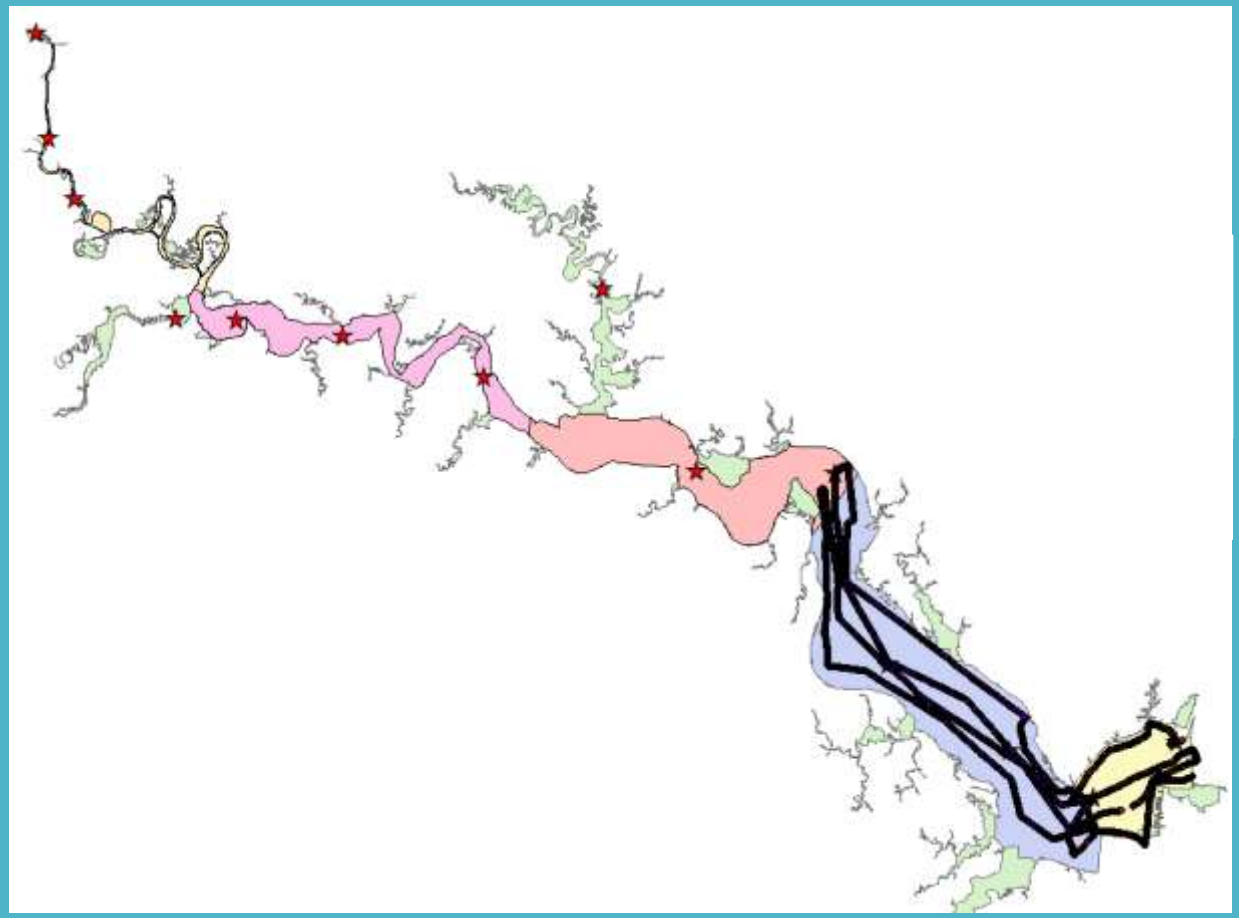
1. Spatial interpolation of monitoring data



JR segment sampled once monthly at five stations.



Chesapeake Bay Program fixed stations (monthly samples)



Fixed stations + Dataflow

How does it work?

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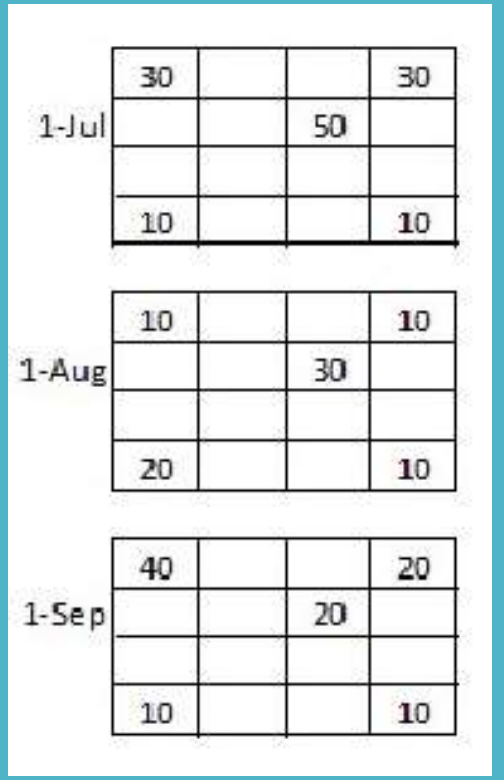

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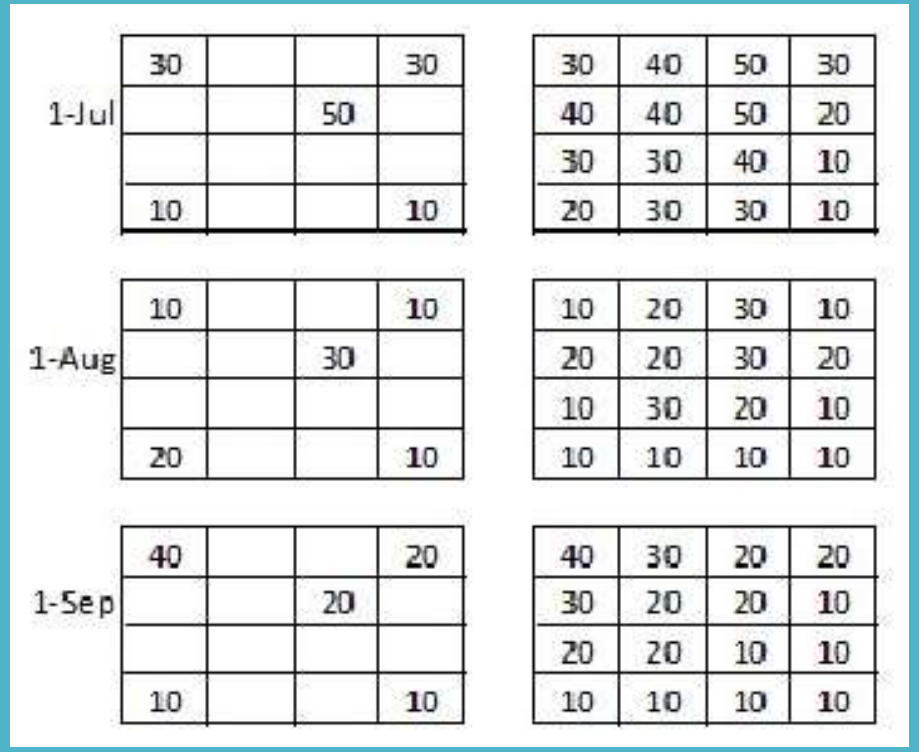
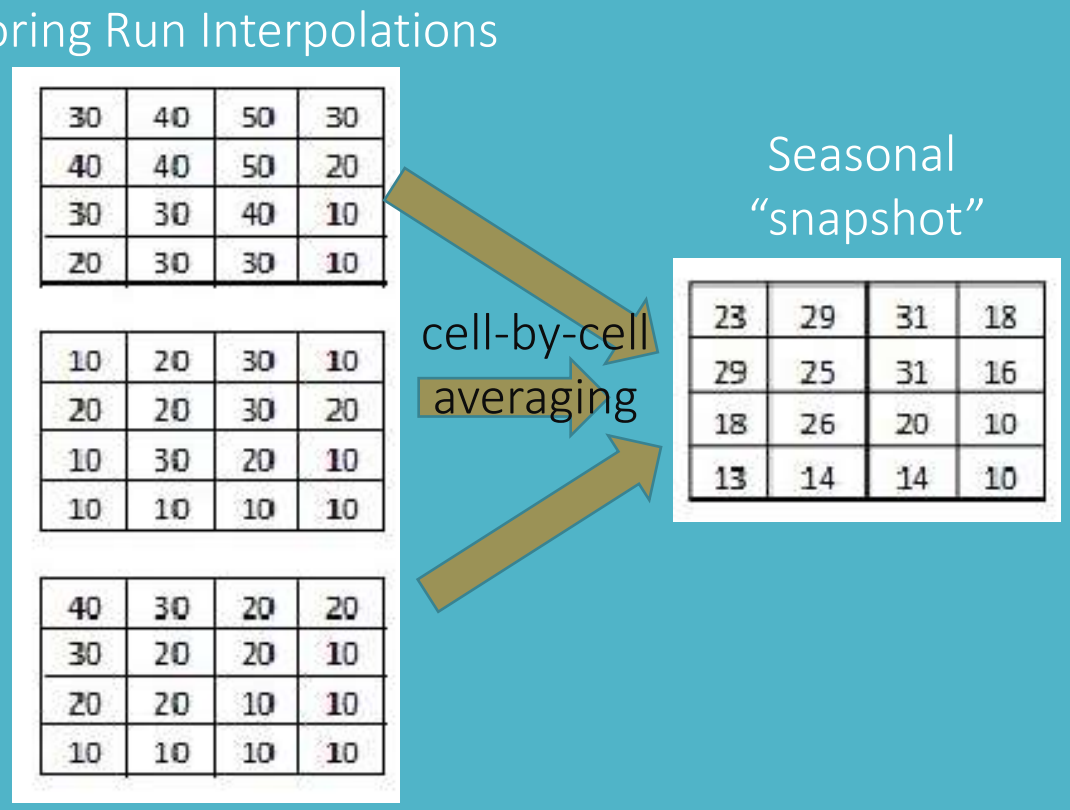


Field observations are interpolated so that the entire segment is represented in the assessment.

How does it work?

Steps:

1. Spatial interpolation of monitoring data
2. Calculation of spatial exceedance rates



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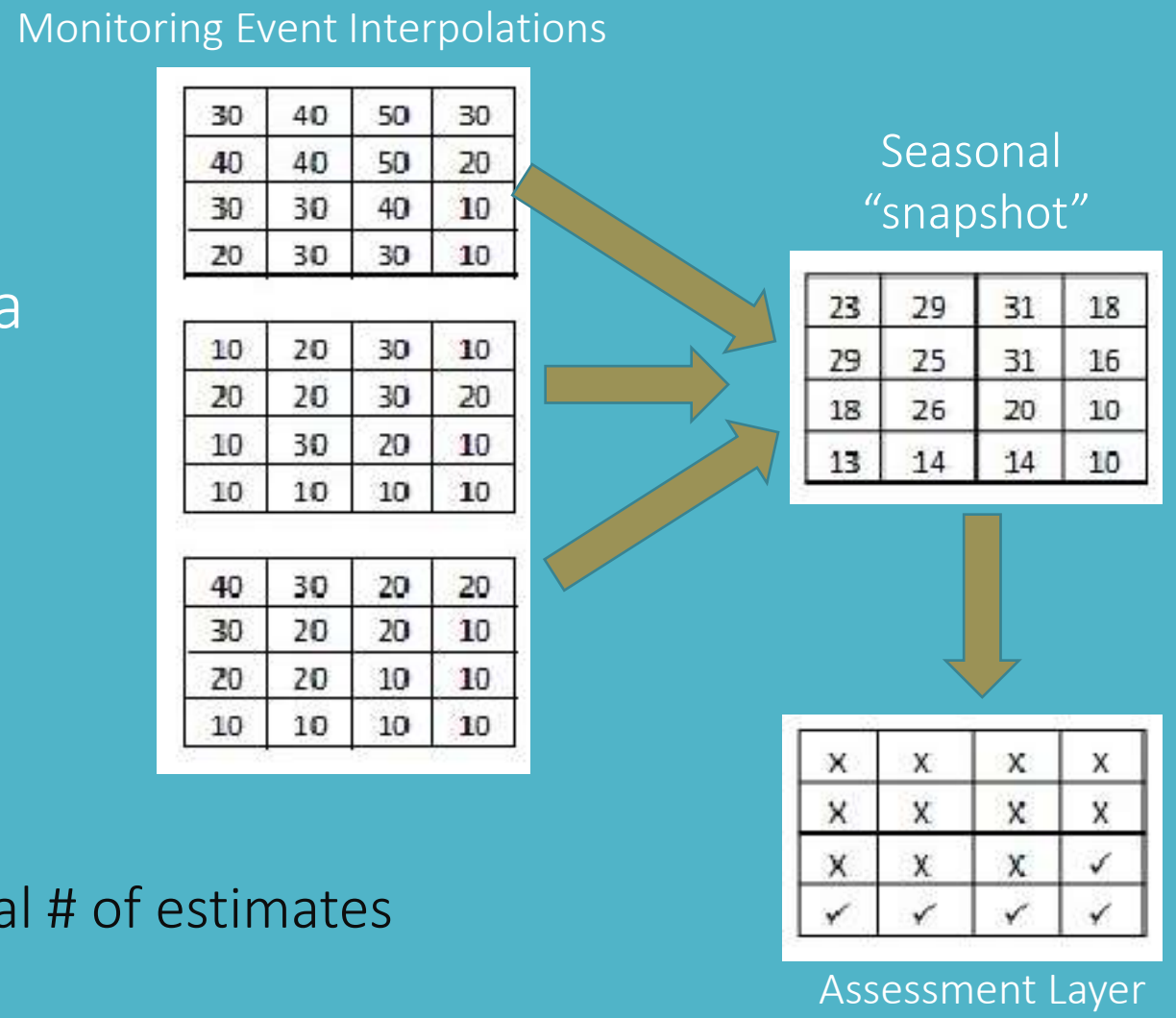

Exceedance rate = # of exceedances divided by total # of estimates

How does it work?

Steps:

1. Spatial interpolation of monitoring data
2. Calculation of spatial exceedance rates
3. Build the CFD

Season-Year	Spatial Exceedence Rate
Spring Year1	25%
Spring Year2	33%
Spring Year3	10%

Three years of spatial exceedance rates

Season-Year	Ranked Spatial Exceedence Rate
Spring Year2	33%
Spring Year1	25%
Spring Year3	10%

Rank them from worse to best

Season-Year	Ranked Spatial Exceedence Rate	Temporal Exceedence Rate
	100%	0%
Spring Year2	33%	25%
Spring Year1	25%	50%
Spring Year3	10%	75%
	0%	100%

Assign each exceedance with a cumulative probability using the Weibull equation

How does it work?

Steps:

1. Spatial interpolation of monitoring data
2. Calculation of spatial exceedance rates
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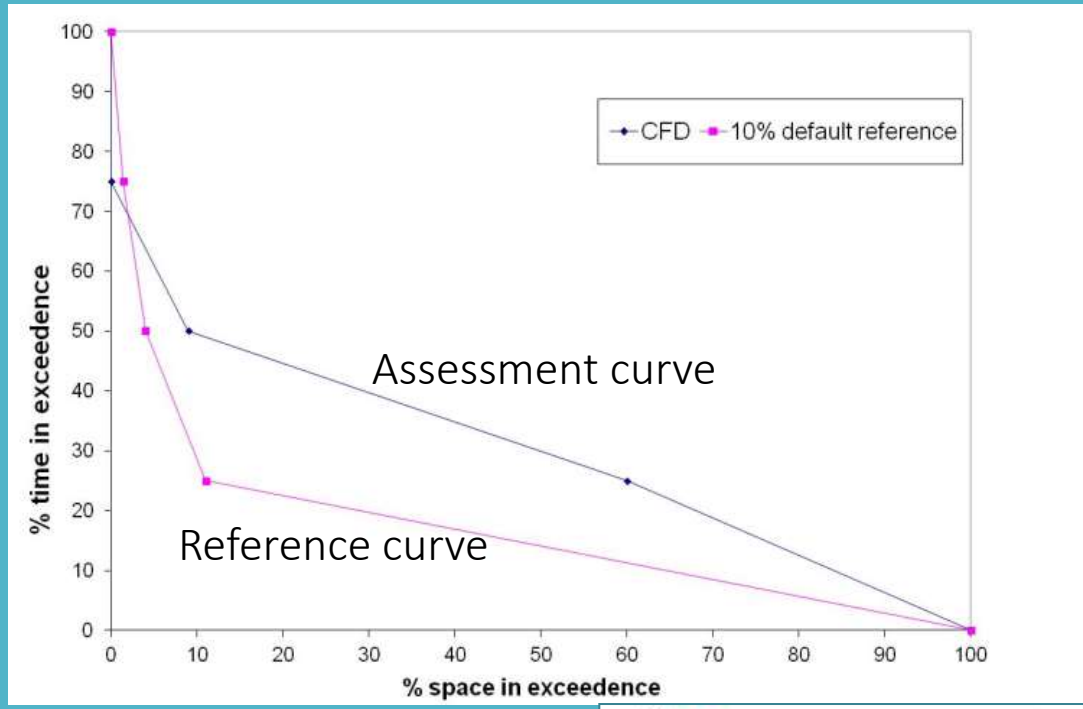

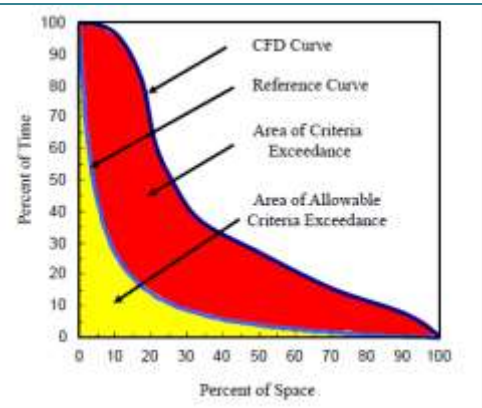

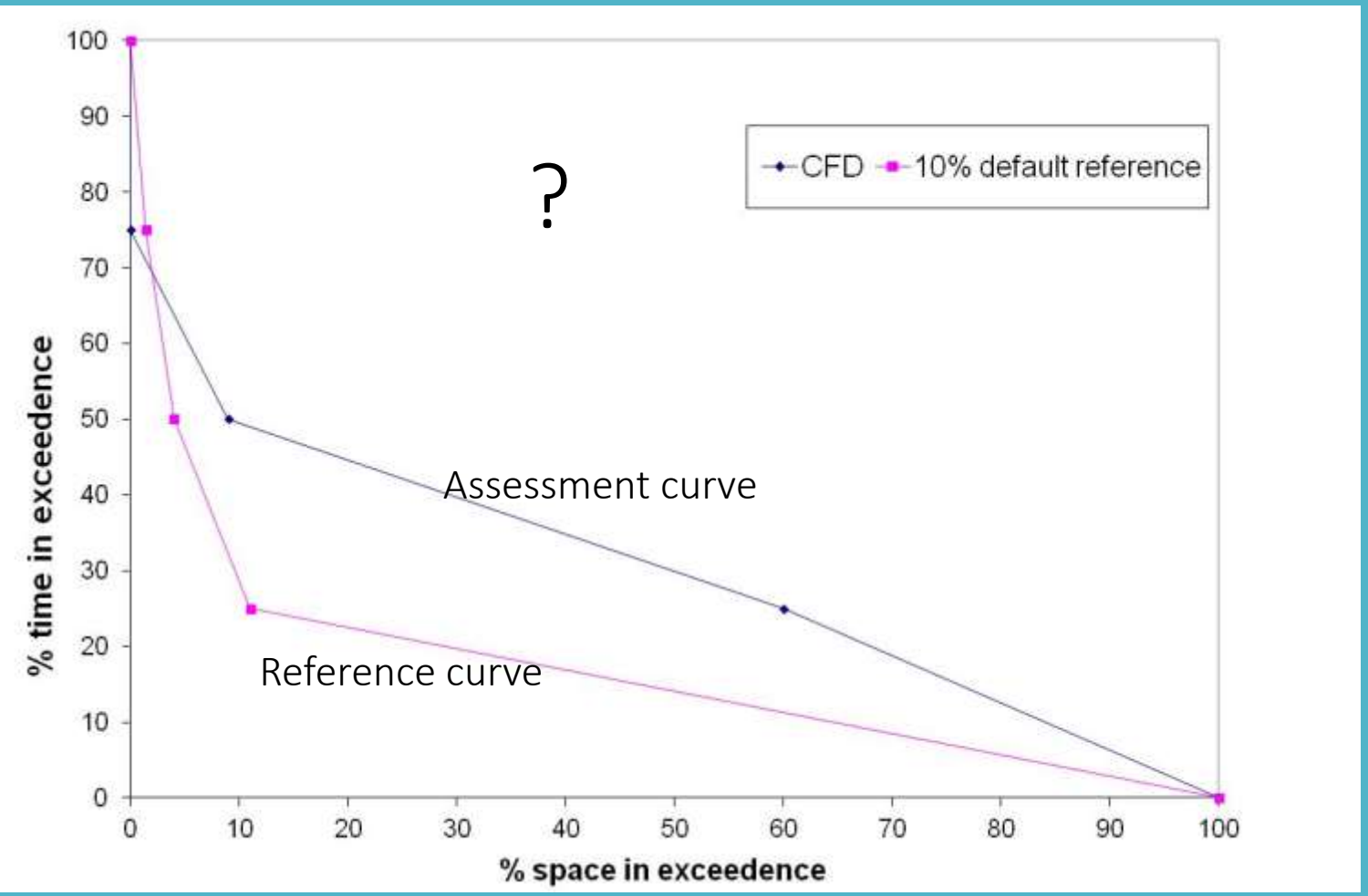
?
CFD
10% default reference
Assessment curve
Reference curve
% time in exceedence
% space in exceedence
100
90
80
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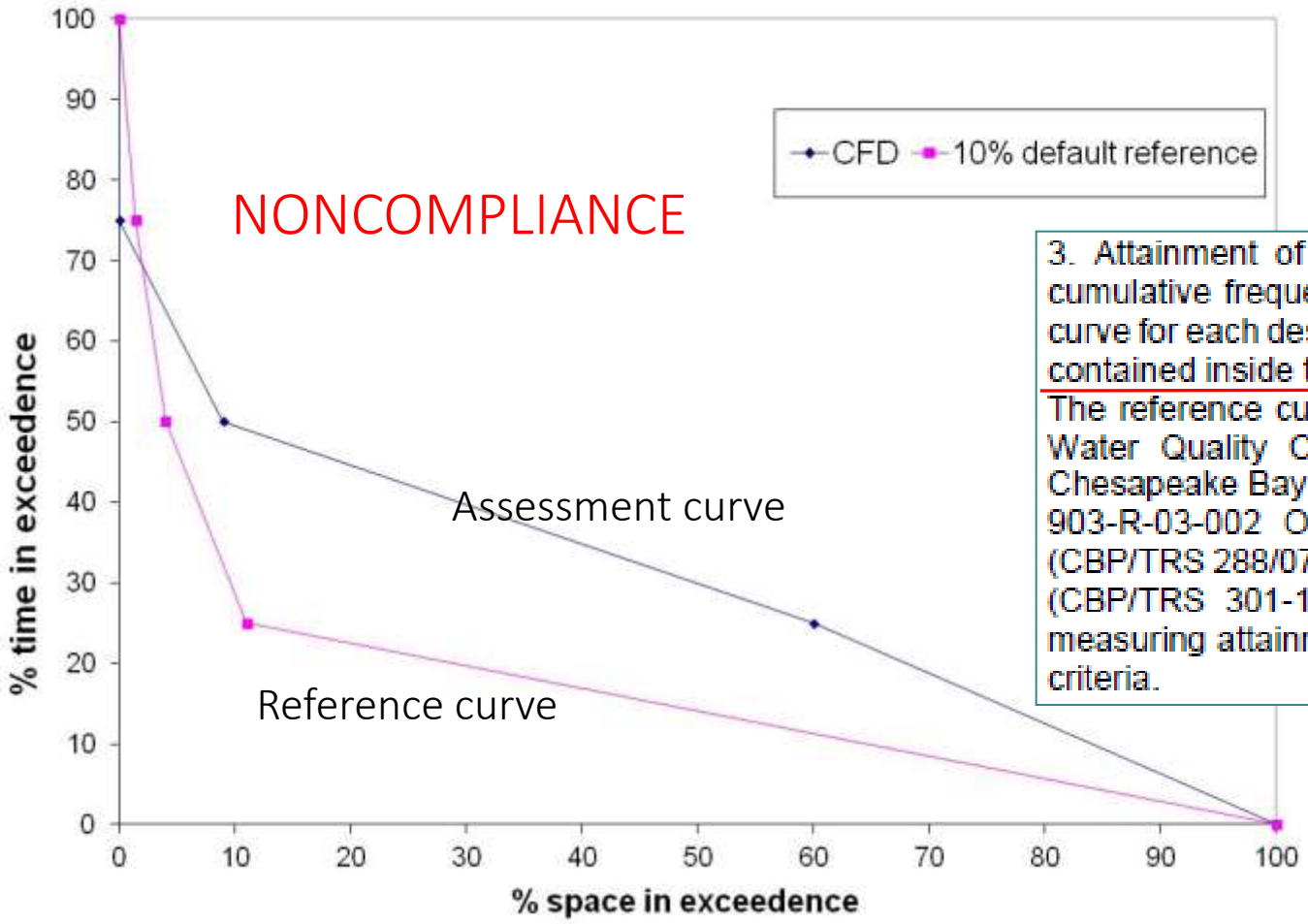

NONCOMPLIANCE

Assessment curve

Reference curve

9 VAC 25-260 Virginia Water Quality Standards

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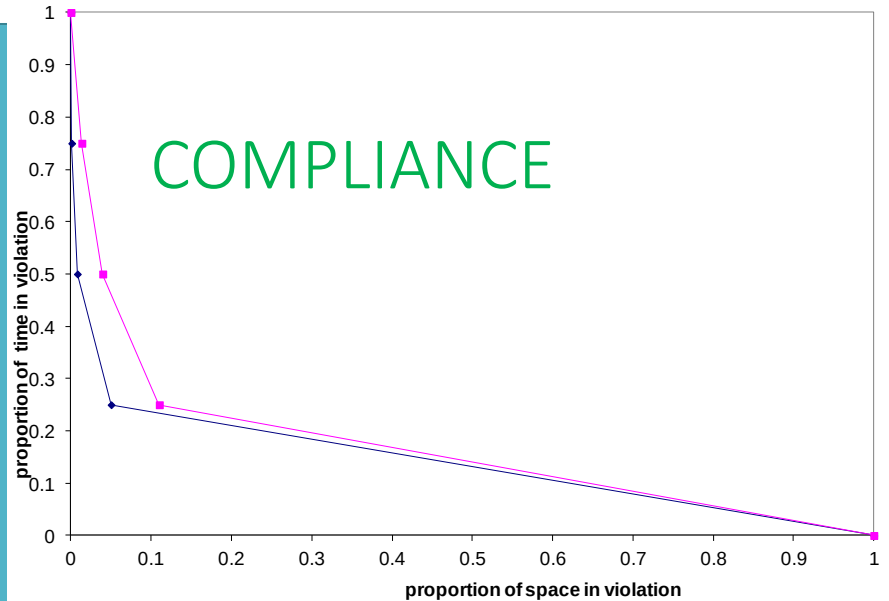


COMPLIANCE

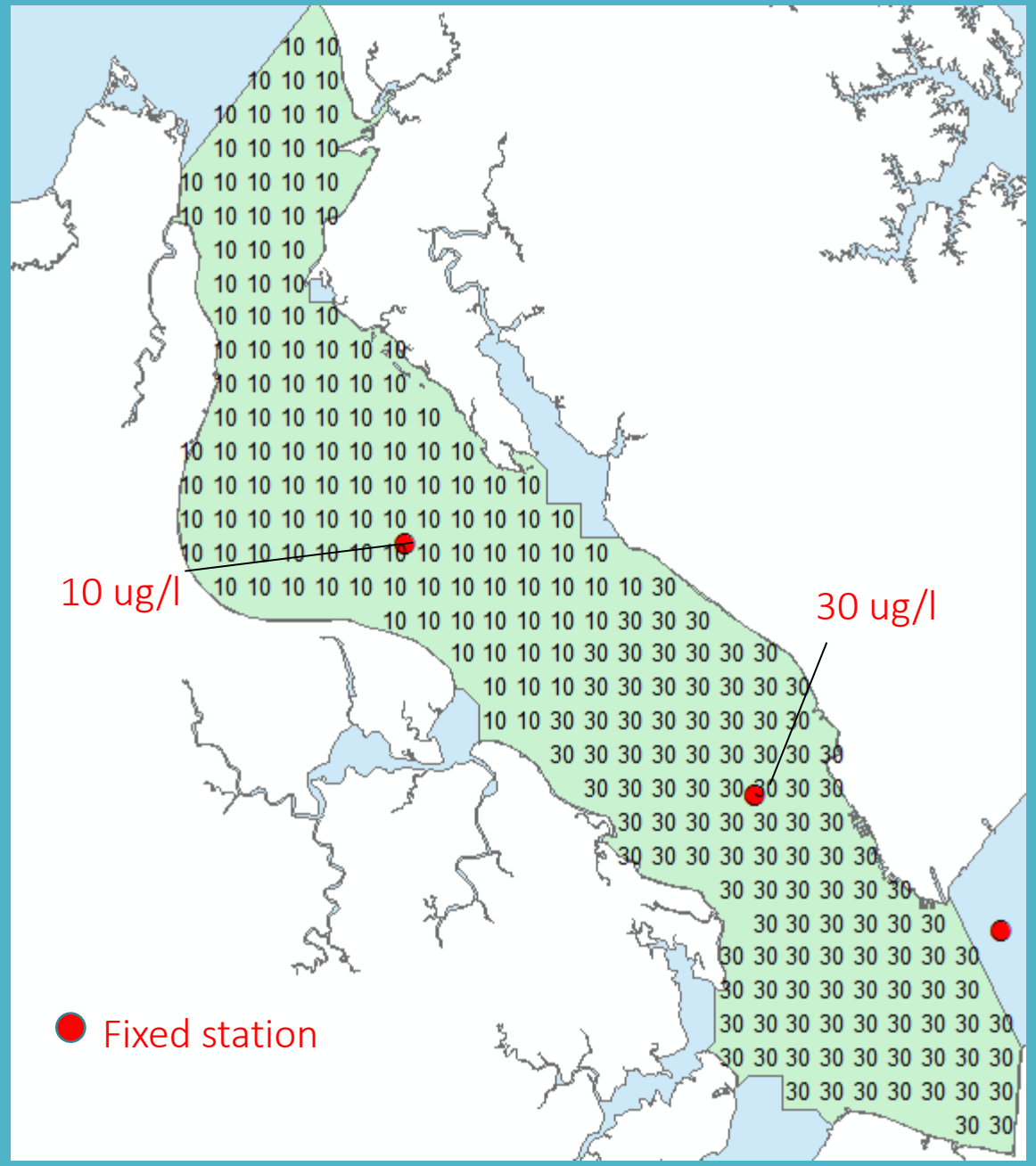
Weaknesses of the CFD Framework Identified by DEQ

The datasets generated from monthly fixed station visits are not sufficient to produce accurate estimations of exceedance as defined by the current methodology.

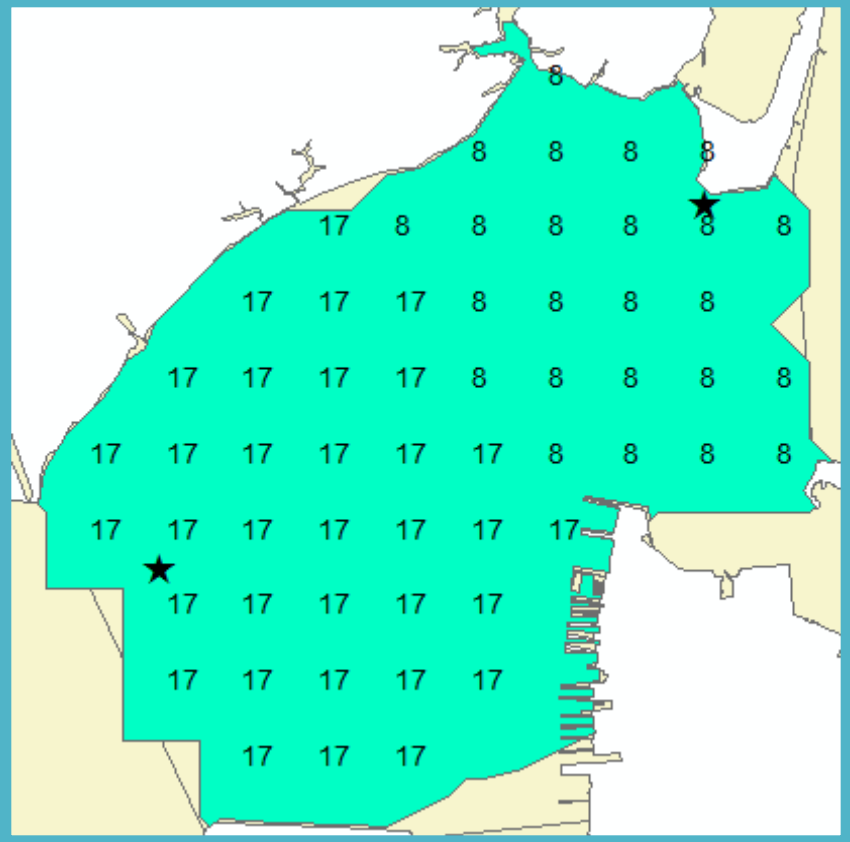
The CFD requires us to make an assumption about chlorophyll spatial and temporal variability under reference conditions. It is questionable that the rubric we are currently using is a good one.

Weakness #1: The datasets generated from monthly fixed station visits are not sufficient to produce accurate estimations of exceedance as defined by the current methodology.

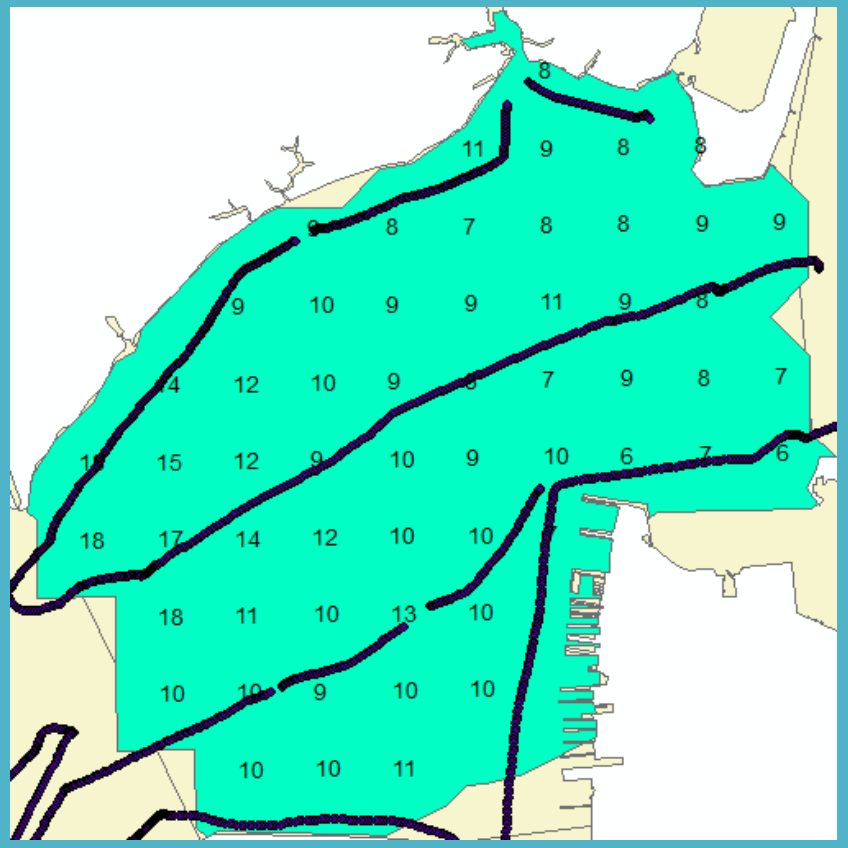
This is what an interpolation of a fixed station dataset looks like.



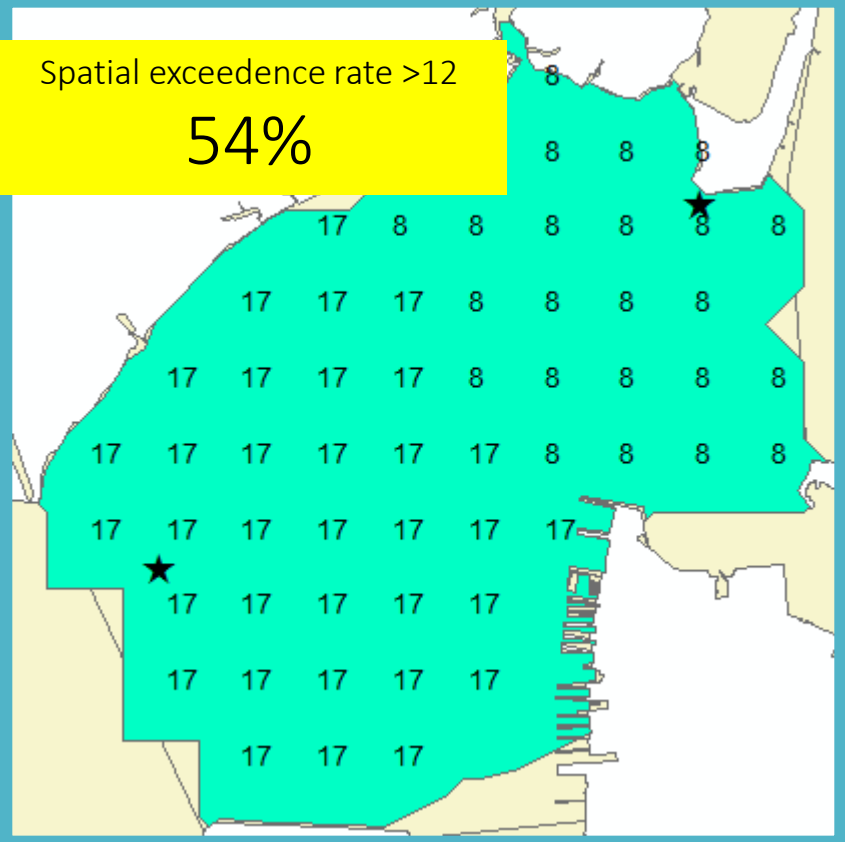
Fixed station datasets produce very simplistic representations of chlorophyll expression compared to the picture painted by Dataflow.



Interpolation based on two data points (represented by stars)



Interpolation based on **1,928** data points (represented by Dataflow cruisetrack)



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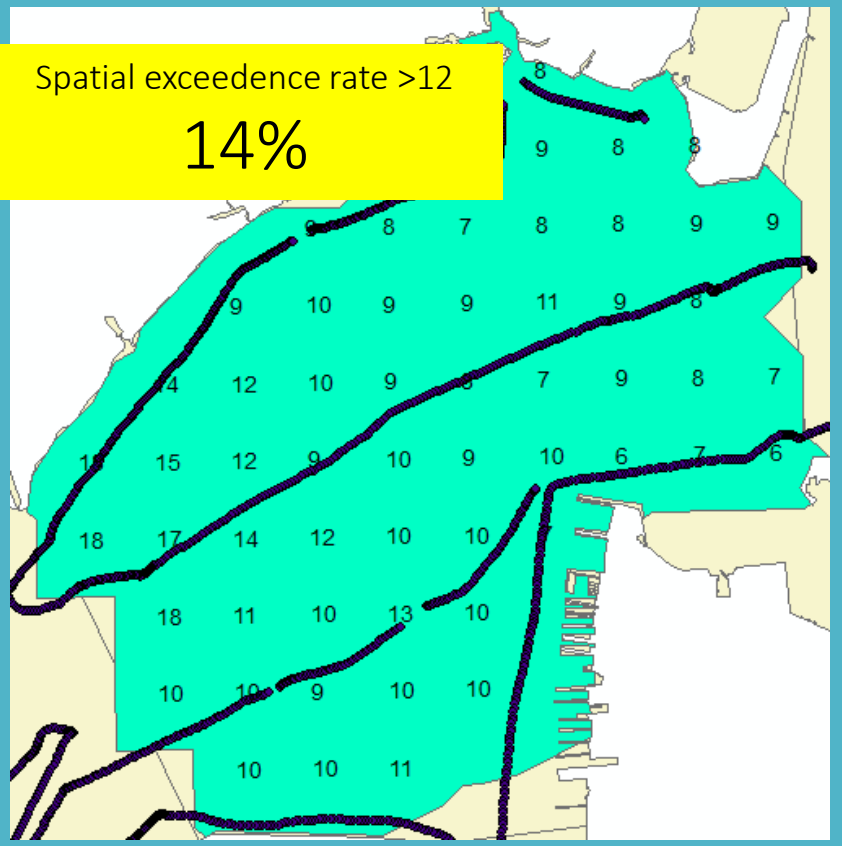

Interpolation based on **1,928** data points (represented by Dataflow cruisetrack)

DEQ contracted with independent statistician Elgin Perry to perform a validation of the CFD when fixed station datasets are used to determine compliance.

His analysis is summarized in the “Critical Review” white paper distributed to the RAP.

The take-away:

"When the true condition of the estuary is either passing or failing, the sample CFD [based on fixed station data] has a high probability of reaching the wrong conclusion. ***The odds of making the right decision are very little better than if the decision were reached by flipping a coin."***

-Elgin Perry

From "Notes on James River Chlorophyll Simulator and CFD Validation"

Weakness #2: The protocol requires us to make an assumption about chlorophyll spatial and temporal variability under reference conditions. It is questionable that the rubric we are currently using is a good one.

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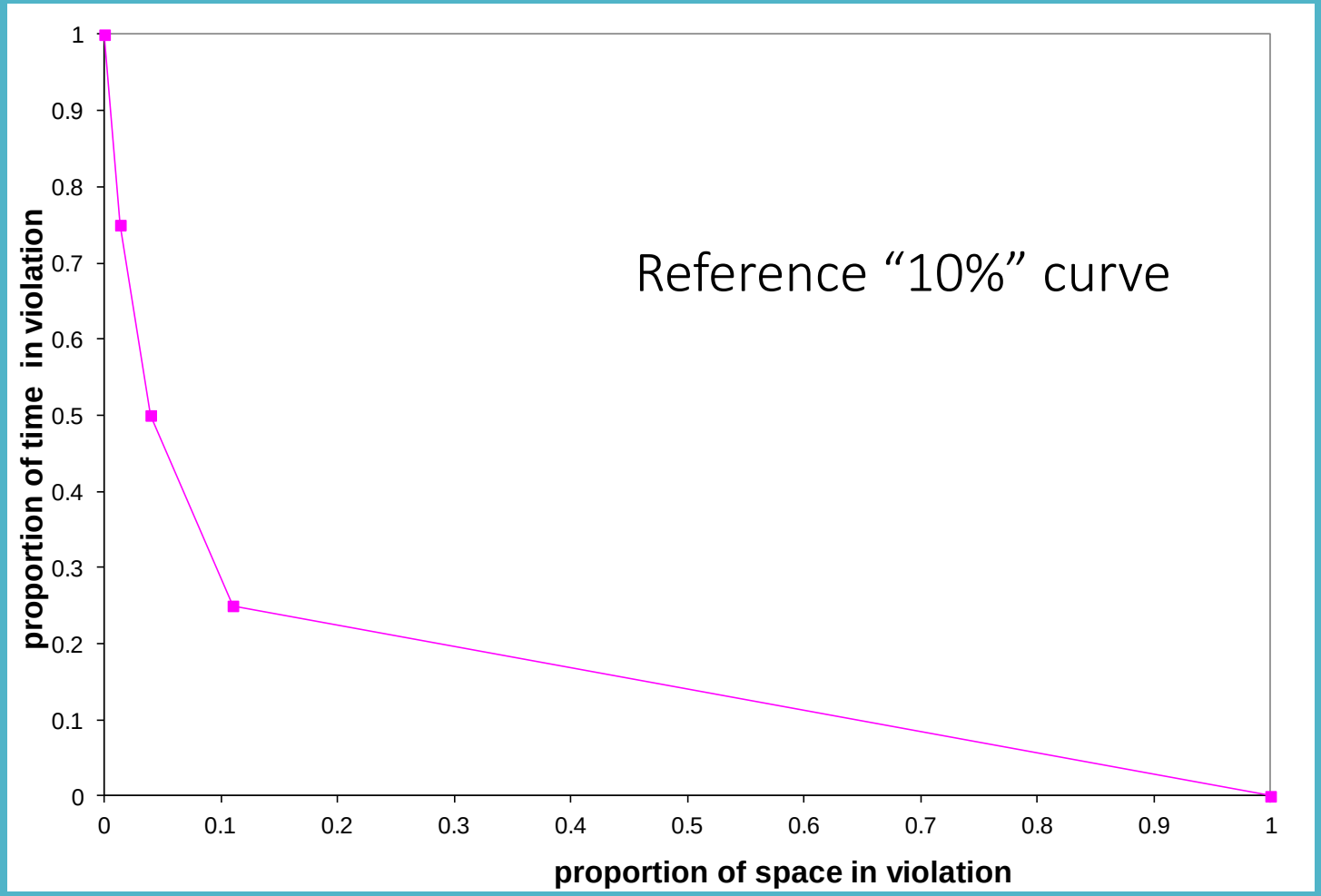
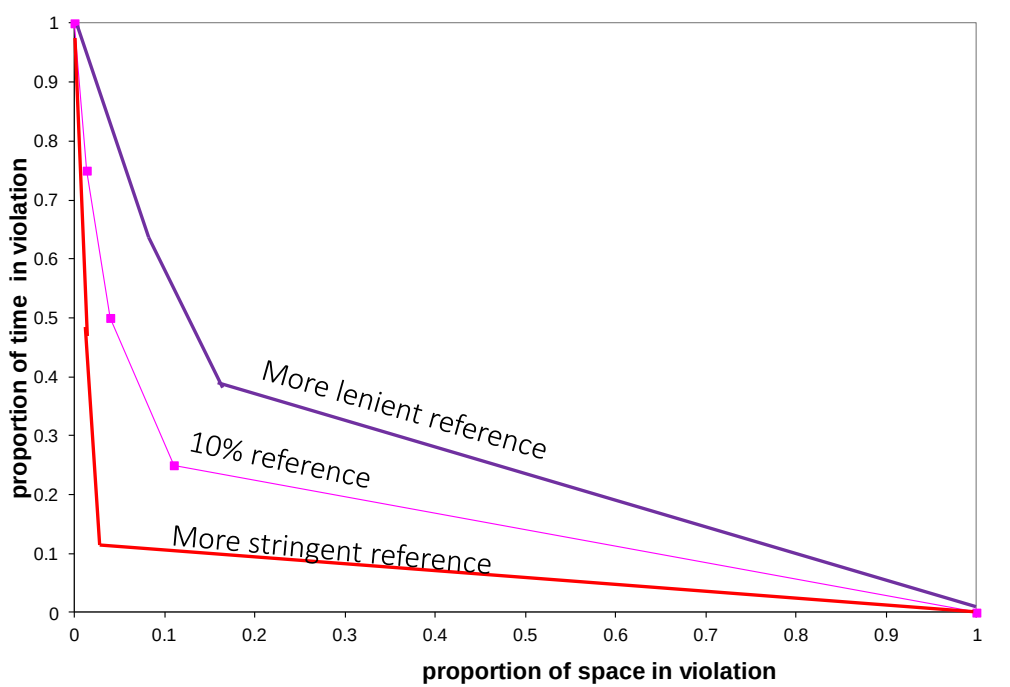


Is this distribution truly reflective of reference conditions, or is it an arbitrary line?

DEQ contracted with Claire Buchanan (ICPRB) to generate “bioreference” curves based on instantaneous exceedances of the JR criteria when nutrients are low and light availability is high (reference conditions).

Her analysis is summarized in the “Critical Review” white paper distributed to the RAP.

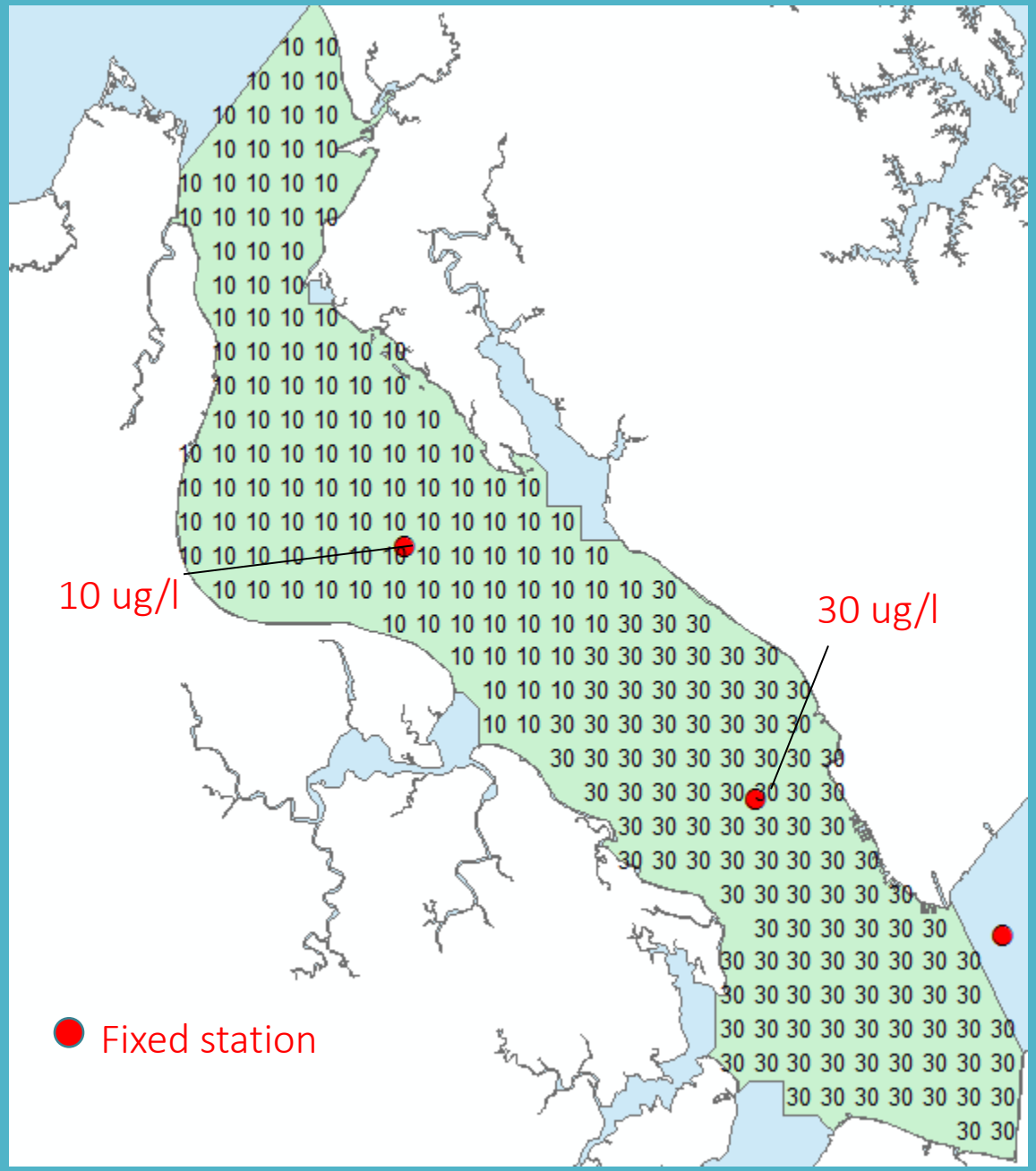
The take-away:

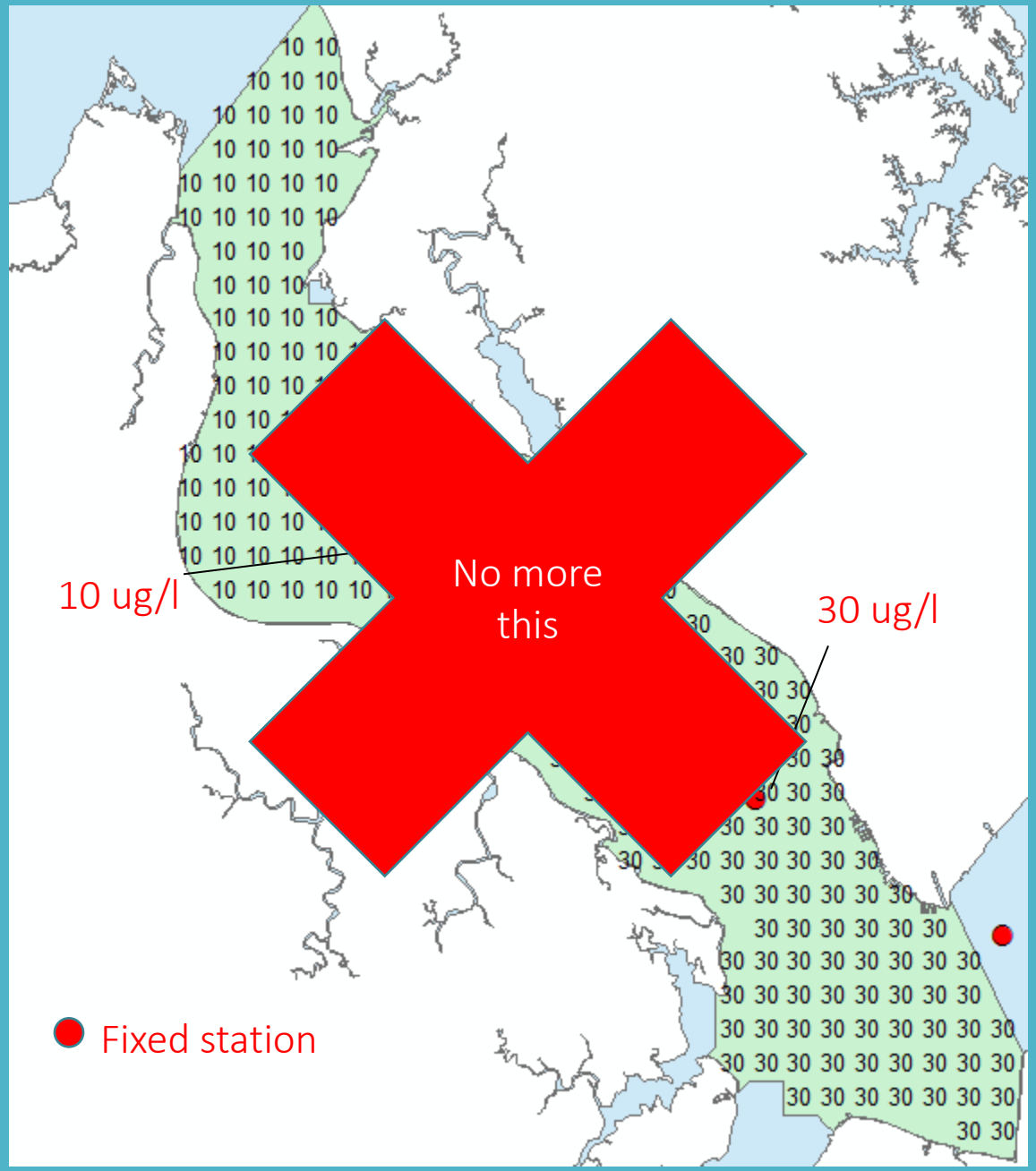


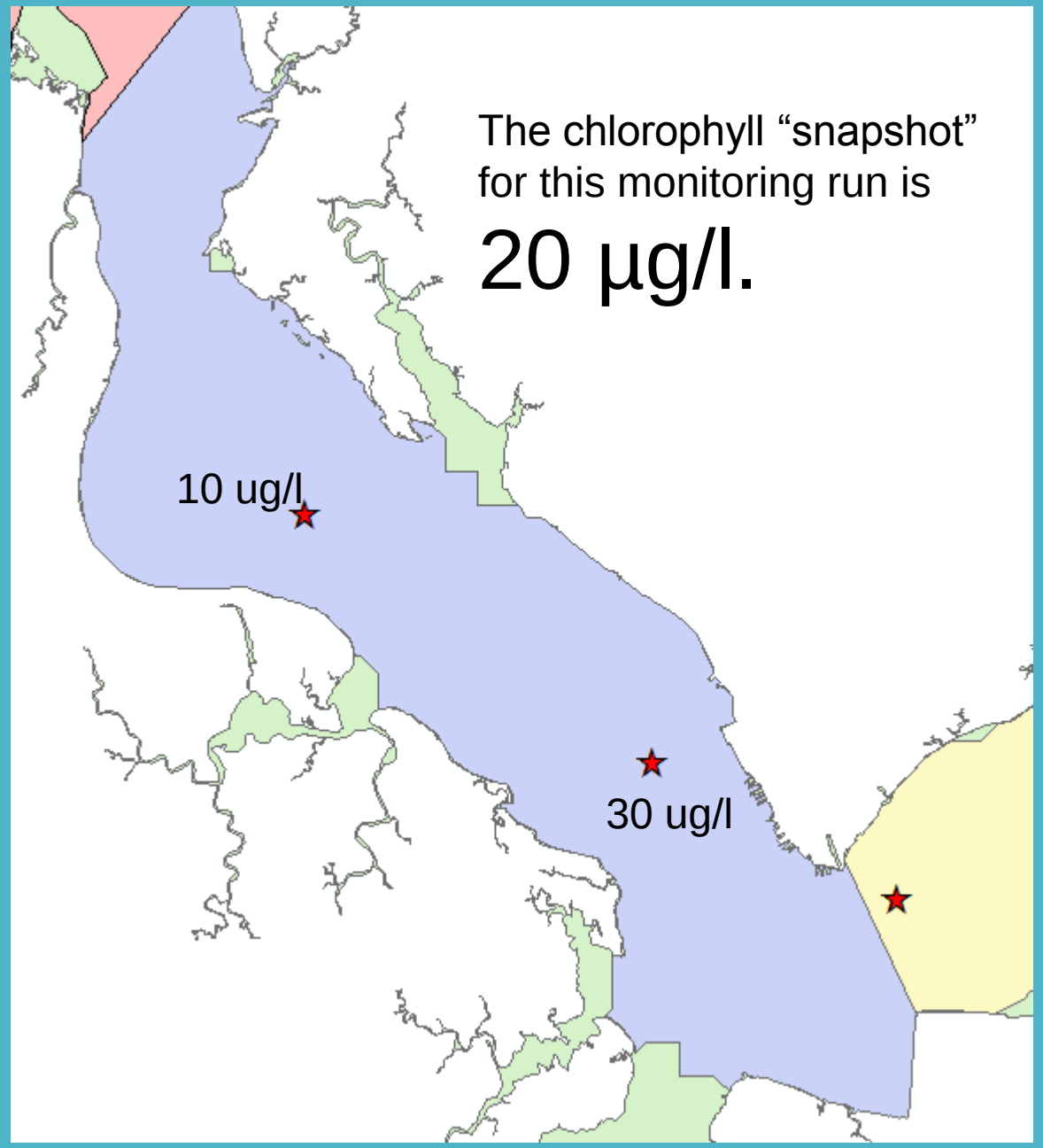
JR criterion	stringency of bioreference relative to 10% curve
spring TF2	slightly more lenient
spring TF1	more stringent
spring OH	much more lenient
spring MH	much more lenient
spring PH	more stringent
summer TF2	slightly more lenient
summer TF1	slightly more lenient
summer OH	similar
summer MH	much more lenient
summer PH	much more stringent

Claire's results suggest that the 10% curve is overly stringent in most cases, assuming that the JR criteria are adequate representations of reference.

DEQ believes the short-comings of the CFD justifies the development of an alternative assessment framework. The proposed procedure is presented in the “Proposed Assessment Methodology…” white paper distributed to the RAP.

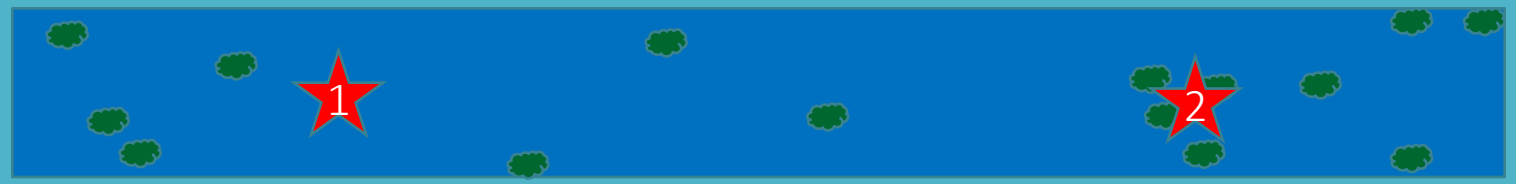

10 ug/l
30 ug/l
Fixed station


No more this
10 ug/l
30 ug/l
Fixed station


The chlorophyll “snapshot” for this monitoring run is
20 µg/l.
10 ug/l
30 ug/l

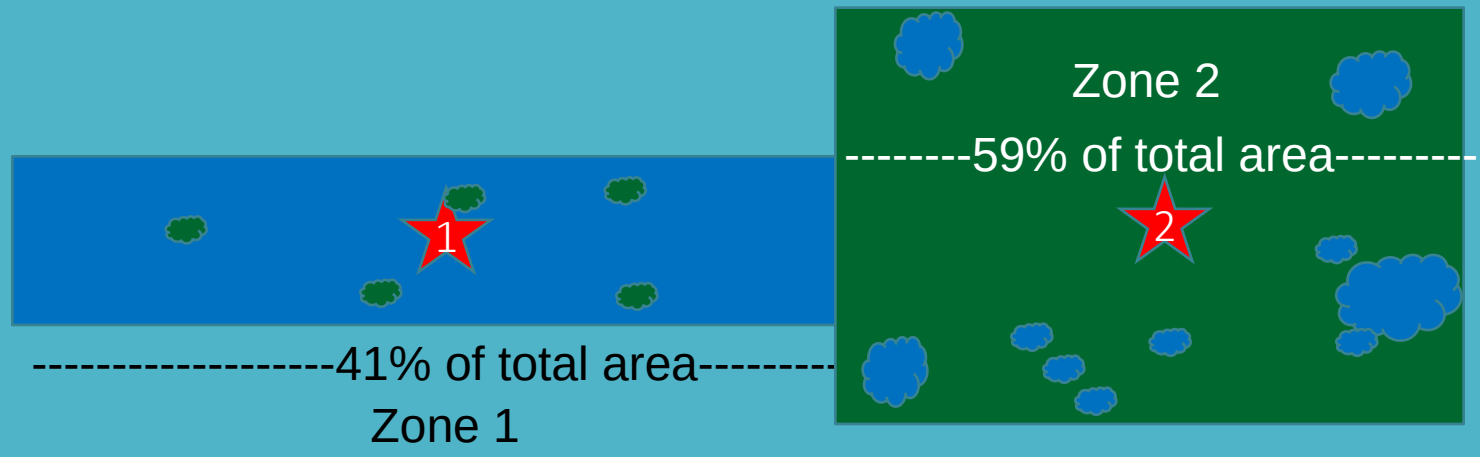
For segments that are spatially uniform…

Monitoring Date	Chlorophyll @ Station 1	Chlorophyll @ Station 2	Composite Chlorophyll
July 15	10	30	20
August 15	5	36	21
September 15	3	27	15
		Seasonal geometric mean (value to be compared to criterion)→	18

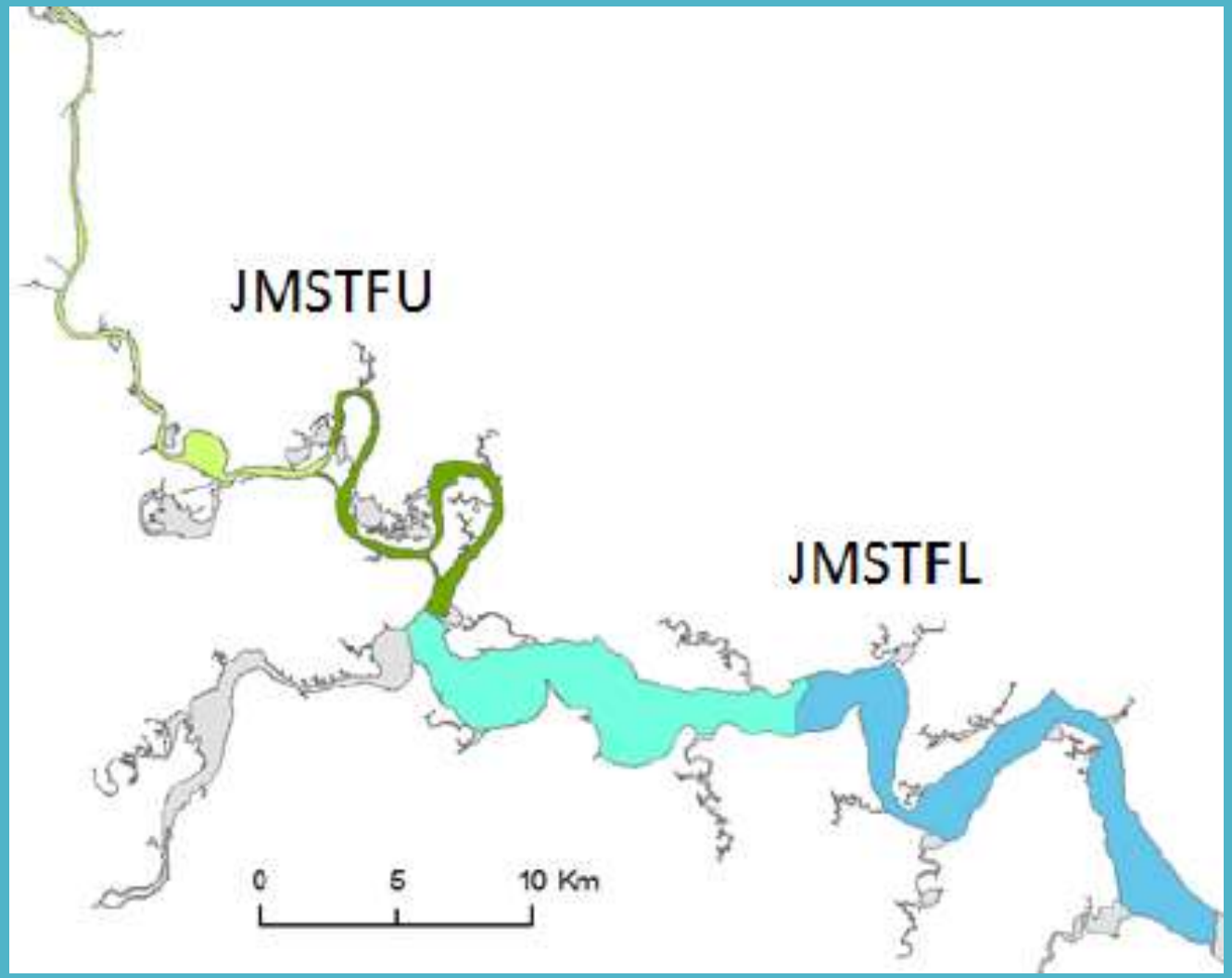


For segments that are consistently non-uniform…

Monitoring Date	ZONE 1 Chlorophyll @ Station 1	ZONE 2 Chlorophyll @ Station 2
July 15	10	30
August 15	5	36
September 15	3	27
"Zone" Seasonal geometric means	5	31
Segment Seasonal Mean (value to be compared to criterion)→	=[5 x (0.41)]+ [31 x (.59)]	20



The two consistently non-uniform segments DEQ has identified are JMSTFU and JMSTFL



Assessment Element	Current Method	Alternative Method
Compatible data types	discrete (fixed station "grabs"), Dataflow	discrete, Dataflow, continuous
Data processing	All observations in a segment are interpolated by monitoring event.	All observations in a segment are averaged by monitoring event. Only Dataflow are interpolated.
Calculation of exceedance	Spatial exceedance rate determined from each seasonal interpolation.	The averages derived from each monitoring event are averaged geometrically over a season to represent a segment's seasonal chlorophyll expression.
Attainment determination	Distribution of exceedances relative to reference curve	Segment seasonal mean is compared to criterion.
Length of assessment period	Three years	Six years
Allowable frequency of exceedance	10% space-time	2 exceedances out of 6 (per criterion)

The alternative method has the following advantages over the current method:

- more literal interpretation of the WQS
- easier to implement and explain
- more consistent with DEQ and EPA approaches/guidance
- fewer assumptions
- produces more confident results, free from bias
- compatible with multiple types of data

Where we are right now

- The proposal is currently being reviewed by the CBP STAC.
- Currently awaiting model output so that attainability with the alternative procedure can be determined.

Questions/Comments?